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U. S. DEPARTMENT OF AGRICULTURE.  
OFFICE OF ROAD INQUIRY.  
BULLETIN No. 8.

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EARTH ROADS:

HINTS ON

THEIR CONSTRUCTION AND REPAIR.

COMPILED BY

ROY STONE,  
SPECIAL AGENT IN CHARGE OF ROAD INQUIRY.

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LETTER OF TRANSMITTAL.

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U. S. DEPARTMENT OF AGRICULTURE,  
OFFICE OF ROAD INQUIRY,  
*Washington, D. C., April 10, 1894.*

SIR: I have the honor to transmit, in accordance with your letter of instructions of October 3, 1893, certain information and suggestions regarding "the best method of constructing a common highway without gravel or stone."

Very respectfully,

ROY STONE,  
*Special Agent and Engineer in Charge.*

HON. J. STERLING MORTON,  
*Secretary.*



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## EARTH ROADS: HINTS ON THEIR CONSTRUCTION AND REPAIR.

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### EARTH ROADS IN DIFFERENT STATES.

#### CALIFORNIA.

The Technical Society of the Pacific Coast, in a paper prepared by Messrs. Streidinger and von Geldern, gives the following instructions for building earth roads:

#### CONSTRUCTION.

In constructing new dirt roads all stumps, brush, vegetable matter, rocks, and bowlders should be removed from the surface and the resulting holes filled in with suitable material, carefully and thoroughly tamped or rolled, before the road embankment is commenced. No perishable material should be used in forming the permanent embankment.

Wherever the subgrade soil is found unsuitable it should be removed and replaced with good material rolled to a bearing. The roadbed having been brought to the required grade and crown should be rolled several times to compact the surface. All inequalities discovered during the rolling should be leveled up and rerolled. On the prepared subgrade the earth should be spread, harrowed if necessary, and then rolled to a bearing by passing the unballasted road roller a number of times over every portion of the surface of the section.

In level countries and with narrow roads enough material may be excavated to raise the roadway above the subgrade in forming the side ditches by means of road machines. If not, the required earth should be obtained by widening the side excavations, or from cuttings on the line of the new roadway, or from borrow pits close by, elevating graders and modern dumping wagons being preferably used for this purpose. When the earth is brought up to the final height it is again harrowed, then trimmed by means of road levelers or road machines, and ultimately rolled to a solid and smooth surface with road rollers gradually increased in weight by the addition of ballast.

No filling should be brought up in layers exceeding 9 inches in depth. During the rolling, sprinkling should be attended to wherever the character of the soil requires such aid. The cross section of the roadway must be maintained during the last rolling stage by the addition of earth as needed. On clay soils a layer of sand, gravel, or ashes spread on the roadway will prevent the sticking of the clay to the roller. As previously explained, the finishing touches to the road surface should be given by the heaviest rollers at hand. Before the earth road is opened to traffic the side ditches should be cleaned and left with the drain tiling in good working order.

#### DRAINAGE.

With wet or clayey roadways surface drainage alone is not sufficient. Without underdrainage the crown of such roadways will dry only by the slow process of evaporation, during which time the topping becomes more and more rutted by the passing traffic. A subdrain in such soils will not prove efficient for more than about

12 feet on each side; hence, two lines of longitudinal subdrains are needed on those parts of our California country roads that pass through wet places, low-lying lands, or clayey soils. They should have an average fall of about 1 in 100; minimum fall, 1 in 1,000. At short intervals, say from 36 to 100 feet apart, are placed cross drains to discharge the water into the side ditches. These cross drains receive a greater fall, say up to 1 in 30. Generally 2½ to 3-inch pipes are sufficient. It is advantageous to bed these tiles in well-rammed brick fragments and to cover them with road metal. Be certain that the tiles are correctly laid and that nothing interferes with their free discharge.

As said before, unglazed round tiles, about 3 inches in diameter and under certain conditions jointed with loose collars, are most suitable for subdrains. The bottom of the tiles should be laid both to the proper grade and below the frost line, after which the tile trench is filled up to subgrade with clean gravel, small field stones, road metal, or broken bricks. The cross drains are also made of unglazed tiles, with the exception of their outlet sections, which should consist of vitrified culvert pipes. Regular branch pipes should connect the longitudinal and cross tiles. On level reaches the lateral roadway slopes for surface drainage should not be less than 1 in 24, and side ditches should be provided, if necessary, as previously indicated. Finally, a rapid discharge of the side ditches, if required, through adjacent lands is of the utmost importance to roadway preservation.

Trees should not be allowed on the sides of dirt roads, because they impede the drying action of the sun and wind. Again, their water-seeking roots are apt to creep into the drains and thus obstruct, if they do not prevent, the junction of the tiles.

#### REPAIRS.

Dirt roads are readily repaired by a judicious use of road machines and road rollers. Ploughs and scoop scrapers should not be used for this purpose. Repairs should be attended to particularly in the spring of the year, and whenever the roadway becomes rutted, subsequently. It is best to commence by lightly scraping at the side ditches, and operating towards the middle of the roadway, following the work up and finishing it with the heaviest road rollers. Holes which are not thus filled should be leveled up with gravel, or other suitable material, and then well compacted with rollers. If possible, these repairs should be executed during damp weather, or at least after a good road sprinkling.

The average cost of the better California country road is \$800 per mile, the price varying between \$400 and \$2,000.

#### VIRGINIA.

Capt. Orris A. Browne, of Cape Charles, Va., says:

I have been requested to give my experience in making roads, and I do so that I may add my mite to a cause in which I am so much interested. This experience has not been gained in the highest, but, on the contrary, in the lowest grade of road-making, namely, in the making of cheap, well-kept dirt roads. Other materials have been used upon them, but in such homeopathic doses that they have not risen above the plane of dirt roads.

My efforts have been those of a farmer trying to supply his own wants, and not those of an engineer. My experience is also very limited in area, having been confined to the eastern shore of Virginia—the two counties belonging to that State east of Chesapeake Bay. The soil of this locality is fortunately so mixed with sand and clay that it forms a very good roadbed, and a little sand on the top of it makes a lasting cushion to take the wear of travel, and when the water is properly drained off an excellent cheap country road is the result. When the soil has too much clay it is easily corrected with sand, and it is surprising how little it takes; the reverse of this treatment is also a success. When the proper combination is made, the road

becomes hard and lasting; so hard, indeed, that when necessary to work it up a Babcock hardpan plow must be used. This implement weighs 230 pounds, and breaks a width of 2 inches, and so hard is this mixture of clay and sand that it requires 6 mules weighing 1,200 pounds each to pull the plow when running 6 inches deep.

Besides the plow referred to above I have a road grader, a heavy farm iron roller, and a farm turning plow. The Babcock hardpan plow is first used to loosen the soil, 6 mules being attached; and this is followed by the turning plow with 2 mules hitched to it. When sufficient ground is loosened the team of 6 mules is put to the grader and the 2 mules are hitched to the roller; the latter is kept on the center of the road all the time; the road is by this means rounded up, smoothed, and made as hard as this roller will make it.

When the wheels cut down in the soil the cuts are filled with oyster shells, and as it is worked down clay, shells, and sand are put in the furrows, and by this means a good hard face is made in the road for the wheels to roll on. The best time to do the work of making and repairing a road, so that the soil will go together best, is just the time when it will do to plow on the farm. These roads can be made for \$100 per mile.

I find, however, that the great point in having good roads is the care of them after they are made. This is not expensive, but it is every-day work. It is absolutely necessary in order to have good roads that it must be the constant duty of some one to look after them after the road is built, especially during and following a rain, that water may be kept off as far as possible. No man can attend to the roads and another business at the same time; especially can it not be combined with farming, for the most urgent work of both comes at the same moment.

#### LOUISIANA.

Dr. Hardey, of Chataignier, La., says :

A road properly made and drained, even in this muddy part of Louisiana, will last for twenty-five years with a little repair when needed. Take common hay, rice straw, or, best of all, bagasse (mashed sugar cane), cover the muddy holes plentifully with it and trample it down thoroughly. Cover this with dirt or mud, then roll it flat, and upon this bed place small poles or brush. Cover this with dry dirt or gravel, trample and roll it down thoroughly, then make a good, wide ditch to drain the road on both sides, and finally roll the surface of the road to make it slope toward the ditches.

A road carefully and properly made in this manner will last twenty-five years with but little repair if the drainage is maintained and slight ruts or holes repaired at once.

Such is my experience of forty years; but all roads want constant care and repair when first needed.

#### WISCONSIN.

Mr. Allen P. Weld, of River Falls, Wis., says:

In our section we find the best method of constructing the common country road to be to turnpike the roadbed, giving wide ditches to be used for sledding when the snow is scarce, and providing for grassing the ditches to prevent washing.

#### NEBRASKA.

Mr. Curtis C. Turner, of Omaha, Nebr., says:

Road scrapers drawn by eight horses are largely used in this county, and have given very great satisfaction when properly handled. Better results could be secured were heavy rollers used in conjunction with them. More care, too, should be used in removing sods and decayed vegetable matter from the roadway.



A recent issue of the Champaign, Ill., Gazette contains the following with reference to the use of a road grader drawn by a traction engine:

The farmers of Newcomb Township are conducting an experiment which is of interest, not only in this county, but in all parts of the State. They have always been opposed to the general schemes for building hard roads at the public expense, and, it is said, have done more toward building good dirt roads than any other township in the county. They have done a great deal toward draining them with tile and with open side ditches and keeping them carefully rounded up in the center. Last fall they tried the experiment of working a grader on them by the use of a traction engine, such as is employed for hauling thrashing machines around the country. The trial was so successful that the engine was employed again this spring, and it began work last week. The expense is only \$8 a day, including fuel, water, and two men. The result shows that the work can be more satisfactorily and rapidly done than by the use of men and teams, and at far less expense. It is estimated that with one outfit all the roads in the townships can be well worked over in two weeks. The experiment proves that it would be profitable to abandon the labor tax system, to raise the road tax entirely in cash, and to hire the work done by means of engines and graders. Good judges say that vastly better results could thus be accomplished at not more than half the ordinary nominal expense. The experience in Newcomb contains a valuable suggestion for the other townships in the county.

#### DRAINAGE AND CONSTRUCTION OF EARTH ROADS.

The following extract is taken from the admirable essay of Mr. Isaac B. Potter, on "Dirt roads and gravel roads" (Good Roads Magazine, vols. 1 and 2):

Water is the great destroyer of dirt roads, and drainage is especially important in the proper making and keeping of the dirt road, because the material of the roadway is more susceptible to the action of the water and more easily destroyed than any other highway materials used in the construction of roads by more elaborate methods. Side ditches are provided for country roads in most cases; but common experience shows how imperfectly these are made, and how inadequate even the best side drains are to relieve the road from its soggy, impassable condition. Nothing brings relief except the slow process of evaporation, and even when a road is dried by the sun and wind it is generally left in a rough, rutty condition.

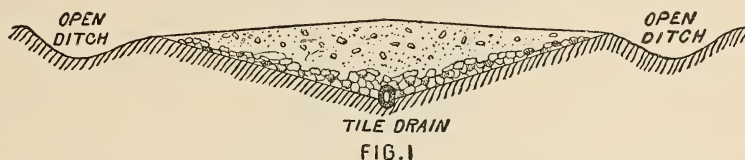
How should a dirt road be drained? A column might be written upon this question alone, for, more than any other, it affects the maintenance of the thousands of miles of dirt roads now in constant use, besides being an important consideration in the construction of new roads. When water falls upon a dirt road we aim to carry it off either by giving the surface of the road a slope to one side or the other, or both, or by underdrainage, in which the water, failing to escape by running from the surface to the side ditches, is drawn into a permanent drain, generally laid lengthwise with the roadway and beneath it, and so made as to carry the water to some adjacent outlet. Let us consider these methods separately.

Most dirt roads have an obstinate tendency to hold water. You may scrape one of these roads into the form of a nicely graded surface and roll it as hard as you please, only to find that the softening influences of the first rain storm will permit the wheels of the first loaded wagon passing over it to make more or less of a depression. This depression serves to hold the water and in this manner the bottom of it is softened and made more susceptible when the next wheel comes along, and so the depression is deepened into an actual rut. I have never yet seen a dirt

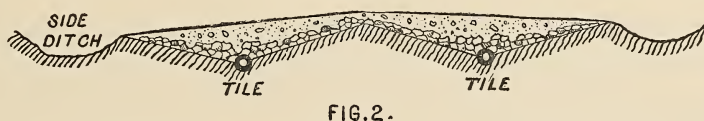
road which offered a permanent and sufficient drainage by side ditches during the wet seasons of the year.

These ditches are often carelessly graded, and always carelessly kept, being generally left to clear themselves, and so neglected that they become obstructed by washings from the road surface and in other ways.

Every dirt road should have a center drain. Give your center drain ditch broad, flaring sides, as shown in Fig. 1, so that the water may be carried down into the



drain from the full width of the wagon track, and if the roadway is made very wide it will be better in the long run to double your line of drain, as shown in Fig. 2. The open waterway in the bottom of the drain may be of tiling, bricks, flat



stones, or fascines, and above this waterway, whatever it be, there should be placed a plentiful supply of common field stones, if they are obtainable. If you are compelled to use earth only, and that of a clayey or loamy nature, you can prevent its working down into the trench only by interposing some kind of a layer of material like coarse marsh grass, straw, or brush.

What kind of drains shall we use? The ordinary drain tile, Fig. 3, used in farm drainage, will be found to answer an excellent purpose, and should be used wherever the question of expense will permit; but if these are not available, irregular or rounded field stones may be used, or fascines may be laid in the bottom, as shown in the separate Figs. 4 and 5.

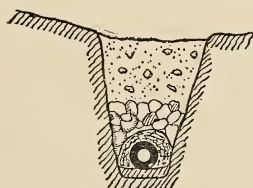


FIG. 3.



FIG. 4



FIG. 5.

Referring to prairie roads, Mr. Potter elsewhere writes as follows:

The slopes of the excavation, which incline downward toward the center drain, should be rolled as hard and solid as possible, after which a layer of several inches of coarse marsh grass should be laid on, with the straws running lengthwise from each side and toward the center of the roadway. Upon these may be placed another layer of grass or straw, crossing the first at right angles. [This presupposes that only the prairie soil can be had.] This method will facilitate draining and drying the upper layer of earth and enable you to use the road during many weeks of the year when it might otherwise be well-nigh impassable.

Fig. 6 represents a form of drain recommended by the Ontario department of agriculture, in a special bulletin on good country roads,

for 1894. This form of drain gives a very free passage for water, but should not be used on any considerable slope, as it is liable to wash out underneath and cave in.

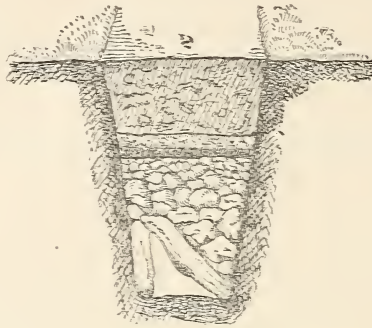


FIG. 6.

A very useful form of drain is presented in Fig. 7 and described in the accompanying letter, which was addressed to the chief of this office by Charles W. Irish, C. E., Chief of the Office of Irrigation Inquiry, U. S. Department of Agriculture:

According to your request I herewith hand you a sketch of a kind of a drain which I have many times put into road constructions for the purpose of underdrainage. I have found that it not only fully answers the purpose, but lasts well. Moreover, when the materials are at hand for its formation, it is the cheapest of all covered drains.

The materials used are a few waste logs and some brush, of any kind handy, and some poles for a covering of the brush. Supposing the trench *e, f, g, h*, is 3 feet wide on the bottom *f, g*. I put in at the sides of it 2 logs *a, a*, each about 8 or 10 inches in diameter. Between these logs I place brush laid crisscross and thoroughly

#### BRUSH DRAIN

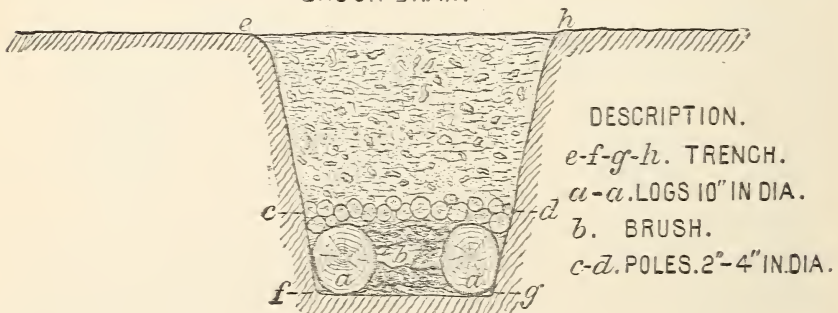


FIG. 7

rammed and tramped into place, filling up the space to a height of 3 or 4 inches above the logs. On the top of the small brush so rammed into place I lay poles, about 3 or 4 inches in diameter, one or two courses deep, and then fill in the trench to the top with earth well rammed.

I put such a brush drain under a railroad embankment of 18-feet fill to drain off the water of a spring which flowed out of the ground about on the center line of the work. This drain remained in action for twenty years thereafter, answering its



purpose completely, and never showing a particle of settling. It was then taken out and a pipe drain substituted for it. The brush and timber seemed perfectly sound after the twenty years' burial.

Upon the subject of the construction of embankments Mr. Potter makes a valuable suggestion, which will be fully appreciated by any one who is accustomed to loading or stacking hay and realizes the necessity of keeping the outer edges of the load or stack higher than the middle to prevent the tendency to "slide off."

Fig. 8 shows an embankment made in the customary manner by



FIG. 8.

dumping material mainly in the center of the roadway and sloping it to the right and left by the usual means, leaving it always higher in the center and with a tendency to slide off at both sides.

The opposite method is shown in Fig. 9, the material having been



FIG. 9.

deposited properly and the surface kept hollowing until finished. For the construction of roads in the prairie or alluvial districts, where no gravel or coarse material is obtainable, the method shown in Fig. 10 is strongly recommended by Mr. Potter. The roadway is slightly raised above the original surface of the ground and thoroughly rolled; then a few inches of brush or coarse grass is put in, the first layer being laid with the ends or fibers pointing across the line of the road and the second lengthwise. The total thickness of these two layers will depend upon the quality of the material used and upon the weight of the top layer of earth which will cover it.

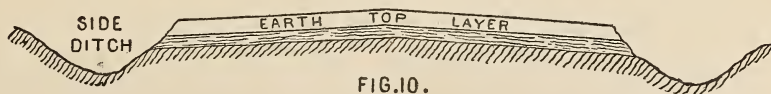


FIG. 10.

In all cases, these layers should not be so thick as to prevent their compacting without undue elasticity or tendency to "give" under the weight of a loaded vehicle. This method does not insure permanent excellence, but as long as the grass or brush layer retains any of its original form and qualities (and this may be for a considerable period), it will greatly hasten the drying of the road after a wet season, and will

tend to quickly drain it at all times, for no reasonable amount of pressure can be exerted by weight upon the road surface that will tend to close or obstruct the little spaces between the various bits of straw and brush. Into these the water will drip in times of rain, and the air also will find its way thither when the drainage has ceased, to the great advantage of the road, and to the satisfaction of its builder.

### TREATMENT OF EARTH ROADS.

The following extract relating to the treatment of earth roads is taken from "New Roads and Road Laws in the United States:"

What has been said in the foregoing chapters clearly demonstrates that all the important roads can be, and probably will be, macadamized or well graveled in the not distant future. This expectation should therefore govern the present treatment of roads everywhere; no labor or expense should be put upon them other than what is necessary to keep them usable, except such as, while it will secure their present betterment, will count also toward their ultimate improvement as hard roads. For this they will require attention (1) to their location, (2) to grading, and (3) to drainage. If the road goes over a hill, which it might go around, the labor put upon it is wasted and the sooner it is changed the better; if it is not well rounded up and surface-drained, it should be, not only for present use but as a preliminary to macadamizing; if it is not underdrained in all wet spots, that should be the first work done; nothing, indeed, will pay better for present use than putting in good tile or stone drains, and they will count for all they cost in the future road building; they should be put in wherever the subsoil is of a nature to hold water.

Hon. W. L. Webber, chairman of the Michigan highway commission, gives this instance of the benefit of drainage in Saginaw: "In this city, a few years ago, the common council, by resolution, placed the drainage of streets under the control of the board of public works, whereupon the board of public works at once let contracts for several miles of tile drains, upon which the council promptly revoked the authority which had been given to the board, the tile drains being regarded as an imprudent use of the public money. But the contracts made were carried out, and after one year's experience the council was so thoroughly satisfied of the advantage of the tile drainage in streets that since that time no street has been ordered improved without ordering tile drains in."

Mr. Webber further says: "Roadbeds should be drained in all places whether subsoil is clay or packed, so that the surface of the road will have no standing water under it to a depth of at least 3 feet, and there is no word which should be so thoroughly impressed into the minds of all connected with the making of roads as the word *drainage*—*thorough drainage*, *deep drainage*."

### TREATMENT OF SANDY ROADS.

The usual way of mending sandy roads is to cover the surface with clay or to mix clay with the surface sand. The Massachusetts highway commission says it is "questionable whether this method of treatment is in the long run economical." The commission estimates the average cost of doing this at 15 cents per square yard, with renewal in about five years, or 3 cents a square yard annually, and adds:

A good macadam road can be constructed for 60 cents a square yard. Taking into consideration the small amount of travel and that the road is estimated to last



twenty years, with hardly any repairs, the annual cost will be 3 cents per square yard, or the same in each case.

Other materials have been used for the more or less temporary hardening of sand roads, and some of them with marked success. For this purpose any strong fibrous substance, and especially one which holds moisture, such as the refuse of sugar cane or sorghum, and even common straw, flax, or swamp grass will be useful. Spent tan is of some service, and wood fiber in any form is excellent. The best is the fibrous sawdust made in sawing shingles by those machines which cut into the side of the block. This has been used to some extent in portions of Wisconsin. The results of its use are described in the following letter from Mr. J. T. Kingston, postmaster at Necedah, Juneau County, Wis.:

Yours is at hand, inquiring in relation to sawdust roads. The officers of this town, Necedah, have for several years past used shingle sawdust on the principal traveled roads in the town. The land is very sandy. Sawdust is first spread on the road from 8 to 10 inches deep, and this is covered with sand to protect the road against fire lighted from pipes or cigars carelessly thrown or emptied on the roadbed. The sand also keeps the sawdust damp. The dust and sand soon become hard and packed, and the wheels of the heaviest wagons make no impression upon the surface. The roadbed appears to be almost as solid as a plank road, but is much easier for the teams. The road prepared in the above manner will remain good for four or five years and will then require renewing in some parts. How lumber sawdust would answer, I do not know.

The ordinary lumber sawdust would not be so good, of course, but if mixed with planer shavings might serve fairly well. Mr. Kingston's statement is confirmed by a letter written from an adjoining county in the same State by Mr. C. M. Simons, county clerk, of Friendship, Adams County:

Your inquiry as to the use of sawdust on sandy roads is received. We have sandy roads in this county, but use no sawdust on them. We use clay and marsh muck. Clay, we think, makes the best road when put on as it should be. Since the introduction of wide-tire wagons (4-inch tires) we have found little trouble with sandy roads. Very heavy loads are being hauled over the sandiest roads with no difficulty on 4-inch-tired wagons; and I consider the use of wide tires on wagons and buggies of far more importance than any road filling that could possibly be done in this county with the means we have at our disposal for the work.

In Juneau County some very fine roads have been made with sawdust. A road of this kind from Necedah to the Wisconsin River, a distance of about 3 miles, is a boulevard of the county and it is a pleasure to ride over it. In that county sawdust is convenient and cheap. In this county roads which have been well graded, and have trenches about 18 inches wide and 10 inches deep, filled with clay, and having about 2 inches of sand on top, just where the wheels run, have made the best lasting roads for all kinds of use, and are the very cheapest we can make. Various plans have been proposed, but no other is so good for the money as the above. Buckwheat, rye, and sorghum straw have been used with good results.

## GRUBBING AND CLEARING FOR NEW ROADS IN TIMBERED REGIONS.

The chief item of cost in building a new road in a timbered country is in the grubbing or digging out the trees and stumps along the line, and this work is so costly that it is generally very imperfectly done, and as a result many years elapse before the roadbed becomes workable through the decay of the roots left in the ground.

The usual practice is to chop or dig out the trees or stumps, leaving the great mass of roots in the ground to be covered more or less perfectly with the earth taken from the ditches. It is impossible in this manner to secure any uniform wearing capacity in the road. In making roads through a forest it has been customary to cut down the timber and then grub the stumps or pull them by machinery, but a great saving can often be made by grubbing the standing timber, cleaning and cutting the roots to such a distance from the tree that only the smaller roots are left in the ground. This is better economy than the other practice; but the grubbing process may be greatly facilitated by the use of an apparatus such as is shown in the accompanying cut (Fig. 11).

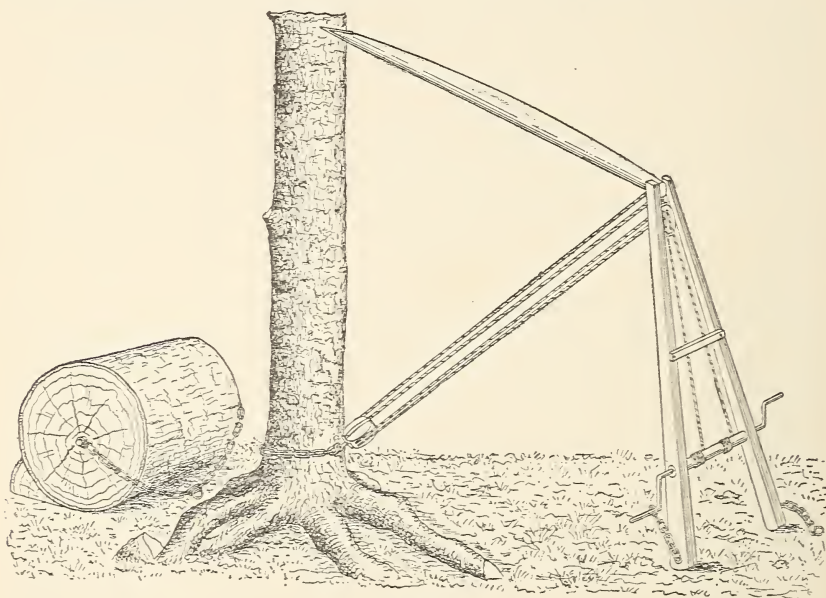


FIG. 11.

A jack or pusher is set up against the tree and pushes it with great force in the direction in which it naturally leans. A few roots are cut on the side of the tree toward the jack, and the weight of the tree itself, with the force of the pusher, easily overturns it. A large roller is placed near the tree to receive it when it falls, and thus pry the roots out of the ground. This process is applicable of course only to forest trees and those having no tap roots.

The most recent practice, in cases where the timber has been cut off and the stumps have to be removed, is to blow them out with dynamite cartridges.

### WAGON FOR DISTRIBUTING CRUSHED STONE.

Referring to a wagon box, designed and built by himself for the purpose of distributing crushed stone, Mr. F. W. Ledyard, of Cazenovia, N. Y., makes the following statements:

The cost of the wagon box, which holds 2 tons of stone, is about \$25. Without any assistant or the driver leaving his seat streams of crushed stone can be poured directly into one rut or both, just in front of the rear wheels, which have broad tires, so that the metal is at once rolled in. This is done when the ruts are wet, and only then. No more stone is applied until other ruts form, and this may not be until another season. No rut, good road.

In this manner 10 inches of stone may be put on during five years, with little more cost than that of wasteful repairs. As the work goes on, ruts will cease forming or be less deep.

This is simply maintenance with comparative permanence in view, and, with a stone-crusher and proper box the process is very economical. I have used hard cobbles in my crusher, and given them a commercial value, so that farmers brought them in instead of putting them in fence corners.

### REPAIRS OF COUNTRY ROADS.

By SARAH COOPER HEWITT, in *Harpers' Weekly*.

So much has been said about the difficulty of making good country roads without involving a great outlay of money that it seems rather presuming to take a contrary view of the subject, but I think the matter has been much exaggerated, and that in any part of the country where clay, hardpan, gravel or disintegrated rock can be found it is quite easy to get excellent roads at comparatively little expense. I speak from some practical experience acquired in road-making in a very wild and hilly region of northern New Jersey, where we are accustomed to work out our taxes on 13 or more miles of public highway, and by adopting the following system we have found it easy to keep the roads in such good condition that they can be driven over at all times with speed, comfort, and pleasure.

The proper time to begin work or repairs is in the early spring, just after the frost comes out of the ground, as soon as the roads have thoroughly settled and dried out. Where the road is old, with a good solid bed, the first thing to be done is to cover it all over with a light dressing of gravelly material, and when possible finish it off with a top coating of hardpan; but avoid putting it on too thickly, lest the going become heavy, as it is slow to dry out. Loam is worse than useless, because it never packs properly, and makes mud. Care must be taken to raise the road up toward the center, and give it a slight elevation at the crown, but only just enough to shed the water on either side into the gutters. On a level, straight road the crown should only be slightly convex, for rounding up a narrow road in the middle is objectionable, inasmuch as it has the immediate effect of forcing wheels of vehicles to run always in the same line and wear away the new material into deep ruts that quickly become water courses for the wash of the next rain, and assist the rapid destruction of the road by preventing the water from reaching the gutters. As fast as the new material can be laid on it should be very carefully raked over to remove all the large stones and as many of the smaller ones as possible; for where this precaution is neglected until the stuff packs down hard, which happens in a few days, the stones become so firmly embedded that they are not only difficult to remove but soon cause the road to wear in humps and bumps, and later



in the season, during the dry weather, they work up continually and become a source of annoyance and danger. These stones should never be left in piles along the roadside, to be driven into or scattered about by mischievous boys or stray cattle, but carted immediately away and dumped out of sight. The gutters should then be carefully cleaned by removing from them all deposits of mud, decayed leaves or branches which have collected there during the winter months; never allow this stuff to be heedlessly thrown along the edges of the gutters or on the banks above them, for the first rains will surely wash all back to its old place, and the work has to be done over again. It is even worse to spread it out on the road, according to the common but mistaken practice of many road-masters, since decayed material can never pack properly, and always tends to make mud in wet and dust in dry weather. Another practical reason in favor of keeping the gutters free just after the roads are first repaired, is that when the heavy spring and summer showers have washed away the greater portion of the good new coating, it is at once caught and retained in the gutters, ready to be used the first time the road needs patching, when a man or two can quickly put it in first-class order by simply shoveling back the material into its old place again and then raking it over.

In the early spring, while the gravel or hardpan is still sticky or heavy, the process of drying out and packing down can be greatly accelerated by keeping some one raking over the road to level off and smooth down the ruts as fast as they are made by the cutting in of the wheels, instead of allowing them to wear down deeper and deeper and to furnish sure channels for the wash of water which adds to the difficulty and expense of repairing. This method is quicker, easier, and far more economical than rolling, which requires a pair of horses, and it is surprising how great a distance a smart worker can get over and put in perfect order during a day. By repeating this raking once or twice, according to the condition of the road and the amount of travel upon it, the surface will pack down quite as hard and even as that of a park road.

Whenever a mud puddle appears, owing to some slight depression, in a place so shaded by trees or shadows of hills that the sun loses its power, it should never be left to dry out slowly, day after day, giving the wheels a chance to cut into it more deeply, but as soon as discovered a cart load of good, dry gravel should at once be dumped into it, then raked off, tramped down, and perhaps reraked until it packs hard and smooth.

Unfortunately farmers and road masters have a fixed idea that the one way to prevent hills, long and short, from washing, is to heap upon them quantities of those original tumular obstructions known indifferently as "thank-you-ma'ams," "breaks," or "hummocks," and the number they can squeeze in upon a single hill is positively astonishing. I remember one hill, less than a quarter of a mile long, where I counted once as many as ten of these horse-killers and carriage-destroyers, yet in spite of these clumsy precautions the hill was always in bad order, and horses obliged to walk up it the whole way. Now, however, since the "breaks" have been removed and replaced by culverts, and the road properly graded and rounded at the crown, horses can trot easily either up or down, and it costs very little to keep the hill in good repair. Of course, much eloquence, tact, and flattery must be expended to bring about the desirable result of inducing the road masters to abandon their most cherished belief, but in the interest of good roads it is well worth the effort on the part of everybody. When "breaks" are done away with, the crown should merely be raised somewhat higher than on a level road, giving it a good pitch to the gutters, which in this case must be sufficiently wide and deep to contain the large amount of running water that often accumulates so rapidly on a hill during a heavy shower as to resemble a small torrent. At certain intervals, therefore, where too large a body of water would collect for the capacity of the gutters, instead of the antiquated "break," a culvert must be introduced, which will afford the means of carrying off the overflow into the adjoining woods or fields.

This question of culverts is really quite an important one, since they bear almost the same relations to roads that keystones do to arches. Culverts made by putting together jointed cement or glazed earthenware pipes are the most satisfactory, being easier handled and comparatively inexpensive, and when laid a certain distance below the surface run little or no danger of being broken. But to obviate this they should be laid diagonally across the road, which prevents the weight of wagons from bearing upon them all at once, and also gives them better fall. An 8 or 12-inch pipe will carry off a large amount of water, but where the volume increases to the size of a small stream a 12 to 15-inch pipe will be found to work admirably. On long hills it is advisable to lay some 8-inch pipes at reasonable distances apart, dividing up the gutters into short sections instead of giving them a free flow down the entire length of hill, and attempting to have the mass of water carried off by means of a large pipe introduced at the bottom, for in case of stoppage at this point the road must necessarily be cut out. Shortening the length of gutters means diminishing the water's force and power to wash away material from banks or to cut so deeply into the road edges. The difference in the cost of small pipes over a large one is not only exceedingly slight, but the little extra expense involved through putting them in is more than saved in one season alone. A short, steep hill needs only a single pipe placed near the foot of the hill. These culverts have one advantage over all others, namely, a concave bottom with a smooth glazed surface, which allows the water to rush through so freely that it carries all obstructions before it and permits no rubbish to choke up the pipes. These require no further attention than a slight examination every spring to see if the frost has cracked a joint, or the ubiquitous country boy has taken it upon himself to stop up the opening by stuffing small stones into it.

When carefully built, stone culverts are not bad, but they are expensive to make well, and, as a rule, their sides are laid up so carelessly in dry walls of such small-sized stones that they are liable to upheave and be thrown down by frost. Moreover, the flat stones laid across the top are often so badly dressed and fitted together that the gravel covering them keeps sifting through the cracks, filling up the culvert and exposing the holes on top, which are either chinked up with cobblestones or left bare until some horse gets hurt and a row is made, with the only result that more earth is spread over, and the same process is kept up *ad infinitum*. Left entirely to himself, the native road master prefers a more primitive culvert of his own make, which has the enormous merit in his eyes of being cheap, quick, and easy of construction. His method, delightful in its simplicity, consists in digging a trench across the road and bridging it over with a few split green chestnut rails cut by the roadside, which are afterwards covered with earth or sod heaped above the level of the road in such a manner as to make a disagreeable "break." Besides its liability to become choked and useless, this sort of culvert is particularly objectionable because it is always neglected and forgotten, being left to rot, until at last some horse's foot crashes through it, and the driver may consider himself lucky if the animal escapes with nothing worse than a slight wrench or scratch. During harvest, when it is almost impossible to get men to do any continuous work not connected with farming, to save time we are sometimes obliged to put in a temporary box culvert, made of planks nailed together like a long narrow box open at both ends. These culverts are a slight improvement on the local ones made from chestnut rails, inasmuch as, being quite flat on top, they do not destroy the road's level surface; but, unless care is taken to have them made of oaken planks, they rot out even more quickly than the others.

It is naturally a simpler matter to keep in good order those roads that have been constructed in the first place upon correct principles; but the so-called "old Revolutionary roads" have such a characteristic way of twisting and winding about or climbing over the highest points of hills to avoid ledges and boulders that they require an entirely different sort of treatment and can be improved only by slowly

and patiently straightening them out through blasting and by removing all obstructions. Any attempt to improve these roads by covering up their rocks and ledges is worse than useless, for the earth can not hold for any length of time on their hard, smooth surfaces; consequently a season's rains are certain to wash away every bit of covering from the roadbed, leaving the stones more exposed than ever, from which doubtless arises the popular tradition throughout the country that stones actually grow. In spite of many repairs, year after year, small stones would keep working up, and the only way we found to prevent this was for several seasons to keep a couple of boys taking out each stone with a pick or crowbar as fast as it appeared, filling up the hole afterwards with the best gravel or hardpan, tamping it down with a shovel, and then raking it over. In this way a smooth, firm roadbed was finally secured to work upon, making all subsequent repairs light and durable. The tops of pointed rocks that stuck up were either knocked off with a sledgehammer or blown up with a charge of powder, and all obstructions in the gutters removed in the same way, the sharp sudden turns in the road modified and rounded off, and the crown lowered to its proper height. It is extraordinary what inexhaustible patience and wonderful constitutions our ancestors must have possessed to enable them to jolt contentedly, day after day, over the same old obstacles, without its seemingly occurring to them to make any effort to remove the obstructions; and on a really bad road how one longs for similar philosophy and such admirable backbone.

Another excellent precaution, but one rarely attended to, is the cutting away of brush and weed growth along the road, particularly around the inside of a sharp turn or bend, in order to enable one to see if any traps are coming from the opposite direction; for in these days of fast driving, when every man imagines he owns a trotter, a narrow winding road becomes dangerous unless means are provided to get out of the way of the "old mare" as she tears around the corner. Brush, when not cut down every season, encroaches with incredible rapidity, and spreads so fast into the gutters that if neglected it narrows the roads perceptibly, and the same thing is true of weeds and grass, although in a lesser degree; they also should be removed at least once every year. Not, however, by the following reprehensible process, which finds great favor in the eyes of roadmasters and farmers, and consists in sending out the "boy" with a yoke of oxen or the "hired man" with a team to run a couple of furrows up and down the gutters with a plow, thereby loosening but not destroying all this vegetable growth, which is then either left to obstruct the gutters with useless ridges or flung out over the road to pack down in all sorts of unequal masses.

The introduction of broad tires upon all farm wagons and carts adapted for heavy-draft purposes alone would do much to improve roads, since half the trouble seems to arise from heavy loads carting over country roads at seasons of the year when the ground is soft. At Tuxedo, where all draft wagons are prohibited an entry unless furnished with broad-tired wheels, the tremendous advantage over the ordinary tires has been plainly proved, for there, even when the roads are softest and at their worst, they never cut up through the constant carting of heavy loads of brick, stone, or lumber over them; for the tires, by being so broad that they can not cut in and hence track in the same place, act somewhat like rollers in keeping the roads hard and smooth. So much might be accomplished in this way if every one living in the country, when buying a farm wagon or cart, would not only make a point of getting one with broad tires, but would at the same time exert his influence to that effect with his friends and neighbors. For could the merit of these tires as road-improvers once become known throughout the country, public spirit alone would cause their use to become general and much of the present trouble arising from the deep rutty condition of the roads would cease as if by magic.



